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Lean Manufacturing in the ceramic industry

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INTRODUCTION

The origin of the Lean concept is older than its name and reaches back to the fifties of the 20th century, when Taiichi Ohno employed by Eijie Toyoda was introducing the system now known as “Just in Time” to the automotive industry. John Krafcik – one of the researchers in the International Motor Vehicle Program, was the first to use the term “Lean production” in 1988, and the term was popularized in the book “The Machine That Changed The World”. Lean management is a method of management that creates such work culture in an organization, which makes all participants of the organization interested in constant reduction of costs, raising the level of quality and shortening the delivery cycle. All this in order to best meet customer expectations and prosper, adapting smoothly to the environment. This concept emphasizes elimination of all waste. Lean Production/Manufacturing/Enterprise can be treated as a new philosophy of enterprise management, a new enterprise organization, or as a system of concepts and management methods. In the ceramic industry, there are very few publications in which the authors (Bhamua, J. & Sangwan, K.S. 2015, Bonavia, T. & Marin J. A. 2006) usually refer to general information related to the elimination of waste and increased work efficiency. Whereas, in the case of Polish ceramic plants, one can find a description of implementations of individual Lean tools, for example 5S or standardization (Kleszcz, D. 2017, Chomicz, J. et al. 2006).

When implementing particular Lean Manufacturing tools, companies attach considerable importance to performing all the preparatory and implementation activities included in the procedures, so that a given tool can start functioning as soon as possible. Implementation of lean concepts should lead to the situation where the right elements are in the right place at the right time. In particular, it is necessary to concentrate on reducing or eliminating waste, overloading employees, and eliminating incompatibilities.

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The most important Lean Manufacturing rules include such issues as (Black, J. T. 2011, Wolniak, R. 2014, Melton, T. 2005):

- Elimination of waste – waste understood as everything that occupies the material or an employee and does not add value to the product.
- Reliability of equipment – machines are involved in the production only when it is required by the production process, i.e. when working on the production order.
- Reliability of machining – all manufactured elements are good (zero rejects).
- Single-stream flow – the material flows on one piece instead of batches. Reduction of inventories in progress – reduction of raw material warehouses, stop warehouses, finished goods warehouse.
- Reduction of rejects.
- Reduction of production time of a production series – acceleration of delivery time.
- Error correction – ways to prevent improper material processing.
- The Kanban system – it is a suction system, the materials are "sucked up" by the production system of the customer's order, i.e. the number of products produced is adjusted exactly to the quantity ordered by the customer (nothing to store), Kanban uses cards that allow material to flow through the value creation chain. Work standardization – which is a system of organizing individual elements of the process, systematization and documentation of these elements. Standardization is made by the team leader.
- Work visualization - the employees learn new tasks through direct insight into the implementation of a given task. Work station control process – there is information and equipment allowing employees to produce and control the product of the appropriate quality on each workstation.
- Production level – adapted to the production needs.
- Production cycle – time needed for accomplishment of a given product, divided by the number of products the customer wants to buy.
- Short retooling times.

IMPLEMENTATION OF LEAN MANUFACTURING

Implementation of Lean allows enterprises to increase productivity, reduce costs and increase flexibility towards their customers (Grycuk, A. 2016). This is particularly important in the case of micro and small enterprises that have to fight large companies for survival on the consumer market .

Enterprises operating in accordance with the Lean concept are characterized by simplified processes, fewer stocks of raw materials and finished products as well as by better quality of products (Mazur, M. & Momeni, H. 2019). Apart from those, Lean may provide them with stability and protect against the crisis (Krasiński, M. 2015) in their enterprises. Not all of the Lean Manufacturing tools are useful for each individual enterprise. Very often, an important element of the selection of tools is the size of an enterprise (Shah, R. & Ward, PT. 2003). Ceramic factories dealing in fancy goods production can most often be included in the sector of small and medium enterprises. Most of the tools are intended for large companies. In the case of other branches of industry, e.g. metalworking, such instruments as: First in first out – FIFO, 5S (Seiri, Seiton, Seiso, Seiketsu, Shitsuke), Just in Time, Kanban, Value Stream Mapping, Visualization, SMED are recommended to be used .After proper adaptation of the

assumptions and principles to the specificity of SMEs, TPM, Standardization, or PokaYoke can also be implemented.

Practice shows, however, that implementation of Lean Manufacturing often also fails: the changes are not maintained and the organization does not profit from the assumed benefits. Estimates of the number of such cases are very high and reach up to 90% (Bhasin, S. 2012). Several dozen barriers to the use and maintenance of Lean Manufacturing have been identified in the literature on the subject.

The main barriers include (Albliwi, et al., 2014):

- Lack of standardization of the Lean implementation process.
- Implementing lean tools without implementing changes in the area of employee relations.
- Lack of commitment of the top management.
- Lack of know-how and support for the management and employees.
- High rotation of the management staff resulting in a lack of follow-up.
- Lean implementation plan maladapted to terms and capabilities of the organization.
- Resistance of employees resulting from the lack of understanding of the Lean concept, caused by the lack of training and fear of losing their jobs.
- Attitudes oriented on gaining fast profit.

The result of research on the identification of barriers in the implementation of Lean Manufacturing instruments in a company producing ceramic fancy goods is presented in Fig. 1.

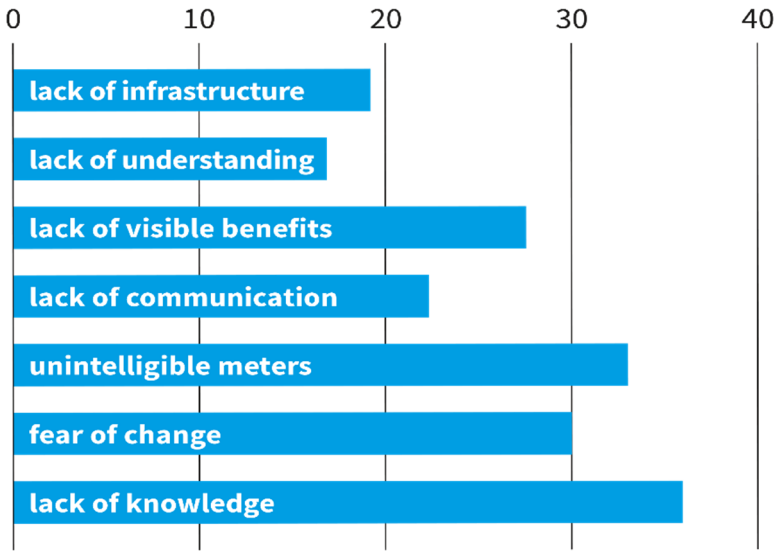

Fig. 1 Barriers and limitations occurring during the implementation of Lean Manufacturing

The research confirms the problems encountered by the ceramic industry in the implementation of Lean instruments. The main problem is the lack of adequate knowledge of the management about the Lean concept, lack of belief in the validity of action and lack of proper communication led to the occurrence of negative effects, among which we can mention:

- lack of an action plan, or a plan of action maladapted to the conditions and possibilities of the organization,

- extending working time,
- increasing work control,
- introducing a large number of unintelligible meters,
- lack of clear, understandable objectives of the organization,
- a large number of post-production documentation,
- lack of understanding of the need to change anything,
- building barriers between managers and employees.

Transformation of enterprises towards Lean should focus, in a synergetic way, on introducing technical and organizational changes, but first and foremost on developing an in-house culture. An important obstacle is lack of the Lean concept model in small and medium enterprises, which, together with the relevant methods could be adapted not only to the specifics of the size of the company, problem situations arising therein and the existing organizational culture, but also taking into account the characteristics of the production industry itself. The implementation of "Lean Management" often faces employees' resistance. Its causes may be, first of all, fear of change and fear of employee layoffs as a result of implemented improvements. An important element is elimination of the barrier of misunderstanding the process of continuous improvement. One of the methods to identify problems with understanding the process of continuous improvement in the organization is to analyze its strengths and weaknesses. An exemplary scheme for identifying disturbances in the improvement process is shown in Figure 2.

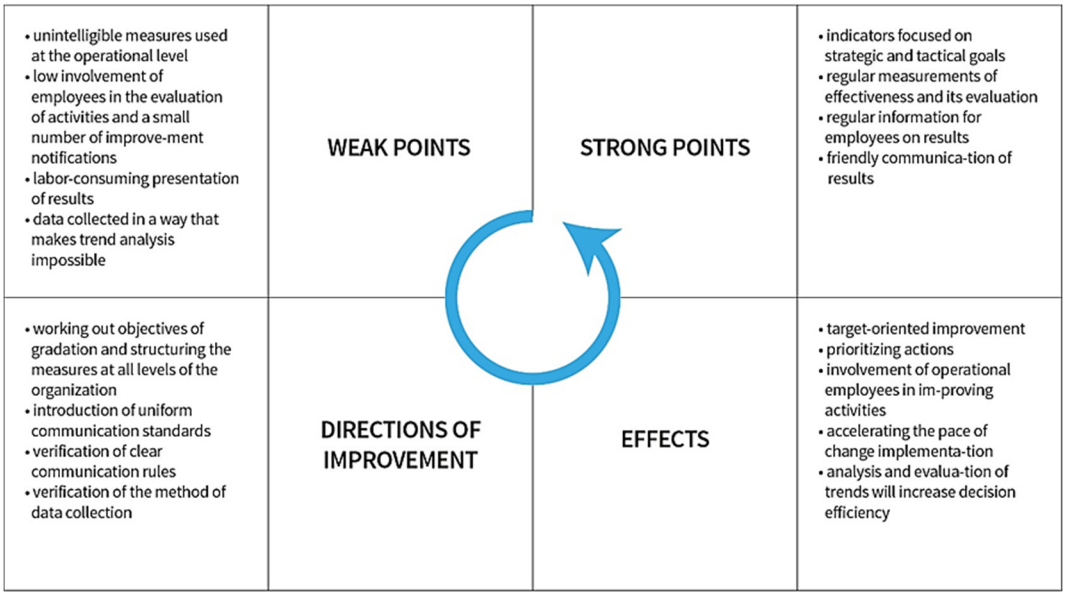

Fig. 2 Identification of barriers in refining processes in the ceramic industry

This approach includes other than Lean methods and tools, management instruments, the use of which is to allow improvement in the operational layer of the organization. Lean Manufacturing cannot be implemented in organizations that do not want to change their way of working. Achieving maximum benefits from the implementation of the Lean is conditioned by the so called soft aspects of management, in particular the extensive use of knowledge and skills of regular employees, related to the humanization of work and by changes in the superiors –

subordinates relations. Implementation of Lean tools is necessary, but support for them must be based on cooperation and continuous improvement of organizational culture. The presented barriers and limitations in the area of soft aspects can be eliminated through training and workshops for managers and regular employees. The problem arises when it is necessary to adjust Lean tools to the organizational structure and production specifics of, for example, ceramic plants.

FACTORS INFLUENCING IMPLEMENTATION OF LEAN MANUFACTURING IN THE CERAMIC INDUSTRY

The ceramic industry focuses around the ceramic plants dealing with the production of various types of assortment (building, sanitary, functional and technical ceramics), and each of these plants is characterized by a different production profile, which causes a problem in the development of one pro-lean solution for the entire ceramic industry. One of the elements common for the entire ceramic industry is the main production process, without which a ceramic product cannot be produced. The production profile of ceramic products varies depending on the type of product range produced and the size of the ceramic plant. There are different sizes of ceramic plants and their production is of individual, serial as well as mass character.

Size of the enterprise

The first major barrier to the Lean transformation may be the size of the enterprise. The results of research carried out in ceramic plants (Kleszcz et all. 2013) correspond with what has been widely described in the literature on the subject and noticed in research on companies from various industries (Nowicka-Skowron, & Ulewicz, 2016; Pacana & Ulewicz, 2017). Implementation of Lean tools in large enterprises is a conscious, well-planned and long-term undertaking. Large production facilities have adequate resources (financial, material, human, information), allowing them to undertake activities related to the implementation of new solutions.

Whereas, in the case of small ceramic plants, there are such barriers as, for example:

- limited personnel resources, especially the instability and variability of employment,
- problems with planning, especially strategic planning, implementation costs, training and consulting, problems with the preparation and maintenance of documentation.

Small and medium-sized enterprises also have negative features affecting the organization and functioning of the enterprise: the managers (owners) of small companies quite often do not have sufficient management knowledge, are distrustful of organizational innovations, do not have the necessary time or formalized methods of data collection. However, in the case of small and medium-sized enterprises, we are faced with opportunities related to the transparency of material flows (products) by the company, transparency of organizational structures (which results from their simplicity), speed of information flow and decision making (short information paths, a small number of levels of management, centralization of basic decision-making powers), lack of anonymity of employees and functions, personal contacts and strong personal relationships, high motivations of employees and managers), which also translates into quick and flexible responses.

Location

Location of a ceramic enterprise is associated with high costs of raw materials. Clay deposits can be found in some regions, and many ceramic plants are located at a long distance from clay mines and processing plants. The delivery of the raw material often takes place in larger batches and causes accumulation of the inventory of the ceramic plant for a longer period of time.

Customer relations

Customer relations, business terms (the size of the assortment, the quantity of ordered products in one delivery, short delivery time, returns of goods) have a direct impact on the functioning of the company. In order to provide reliable and timely delivery of orders to customers, ceramic plants collect products in the finished goods warehouse. This state of affairs is an obstacle in eliminating waste and implementing a tool responsible for levelling production (Heijunka).

Production system

The company type of production system in force determines the flow of materials and semi-finished products during production orders. Characteristic feature of the production environment in which many ceramic plants currently operate is the organization of a continuous production system. The production system is determined by the firing process taking place in roller or tunnel kilns. The continuous production system forces the planners responsible for production to the appropriate prior preparation of the batch. The continuous heat treatment process is extremely demanding and can be a real cost problem associated with extinction and restart of the kiln. Another, additional problem is the fact that ceramic factories producing ceramic fancy goods or building ceramics are exposed to fluctuations in the sale of products due to seasonality. The barrier associated with the continuous maintenance of production affects the storage of inventory. Losses caused by overproduction or shortage of products are an obstacle in eliminating wastage.

According to the Lean concept, the company should adjust the production volume to the sales volume. However, it is difficult to predict trends in demand for particular assortment groups. Sales data from previous periods do not always correspond to the current market situation. In this situation, it is difficult to implement a suction system based on the actual customer demand and thus it is difficult to maintain the actual efficiency of the production line. Manufacturing bottlenecks are another problem. A small number of machines and devices as well as uneven demand from customers leads to high, not always desirable warehouse stocks, which may turn out to be a big problem after the end of a given season. Therefore, the type of production system, bottlenecks and seasonality are major barriers to the implementation of production based on the actual demand of customers in line with the Lean philosophy.

Labor market

Labor market – employee market causes problems with employing people possessing appropriate qualifications. The skills that people working in ceramic plants possess, are an essential element of the company's operations. Work hygiene, diligence, proactivity on the part of employees have a direct impact on the quality of manufactured products, maintaining cleanliness in the workplace (5S), compliance with standards

(Standardization), work flexibility (SMED), improvement of the enterprise (employee suggestion system) (Klimecka-Tatar, D. 2017).

The assortment and the degree of modernization of the company

Producers of ceramic products (ceramic accessories, ceramic tiles, clinker, tiles) compete with one another, offering their clients a modern, often changing design (changes in design and shape introduced several times a year). Customers are more and more demanding, and an enterprise that is attractive on the market must offer not only products of high quality and low price, but also products with an interesting design. A wide and dynamically changing assortment in relation to a limited number of machines and devices results in a situation in which managers must carry out production based on inventory.

CHARACTERISTICS OF THE RESEARCH OBJECT

The research was carried out at the Ceramik company, which we can be considered as part of the SME sector. The company has been operating on the market since 1999, and from the very beginning it has been focused on the production of ceramic accessories. At the beginning, the company produced various types of ceramic products (vases, figurines, lamps, fragrance houses and other decorative items), mainly using a traditional method of making, consisting of casting slip (slurry) into plaster molds. The production consisted of the following processes:

- preparation of the main raw material (grinding of clay in ball mills),
- forming (casting slurry shards into plaster molds),
- cleaning products (washing over),
- heat treatment (biscuit firing)
- decorations (manual under-glaze painting),
- glazing
- re-heat treatment (hot firing).

The applied technology was characterized by an unsatisfactory level of productivity, which led to technological changes. Currently, the course of the production processes of ceramic products consists of the processes shown in Figure 3.

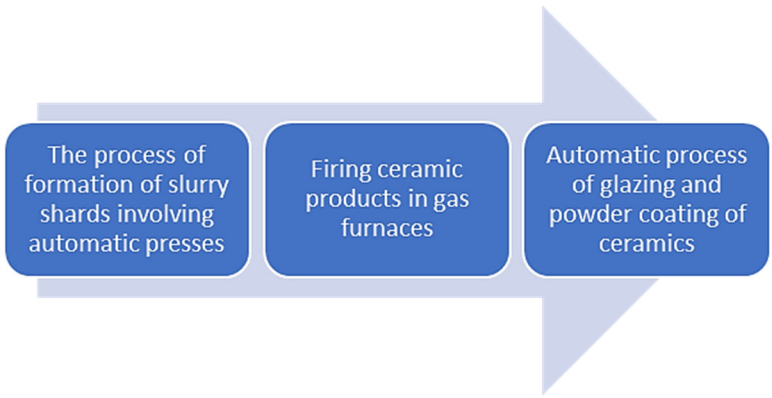

Fig. 3 Processes of production after modernization

CHARACTERISTICS OF THE RESEARCH OBJECT

Surveys were carried out, using the PAPI method (Paper & Pen Personal Interview), among all employees of the research facility. It should be emphasized that the employees had knowledge not only in the scope of implemented processes but also the basics of the Lean concept. This is not a very common fact. The top management of the analyzed company are very much involved in the process of improvement of production processes and in the fight against waste.

The practical use of Lean requires making use of numerous management methods and tools. Respondents were asked to identify tools and lean methods they knew and used in a ceramic plant that produces ceramic fancy goods and their impact on the elimination of waste (MUDA), overload of people and machines (MURI) and elimination of volatility (MURA).

Respondents pointed to the following instruments: 5S, value stream mapping (VSM), Kazien, SMED, Just-in-time, suction system, Total Productive Maintenance (TPM). Standardization, A3 report and 5 x why. Allocation of individual instruments to particular areas of improvement, i.e. the elimination of waste, by the respondents is presented in Table 1.

Table 1
Results of surveys of selected lean instruments in individual areas of waste elimination in a ceramic plant producing ceramic fancy goods

Instruments	Elimination of waste	Elimination of overburden	Elimination of volatility
5S	●	◕	◕
VSM	●	◑	◑
KAZIEN	◑	◑	◑
SMED	●	◑	◕
JIT	●	◔	◑
Suction System	◕	◔	◕
TPM	◑	◑	◑
standardization	◕	◑	●
Report A3	◔	◔	○
5x why	◕	◕	◔

○ no use , ◔ small use, ◑ medium use,
◕ wide range of use, ● very widespread use.

The obtained results showed that in the employees' opinion, the elimination of waste (MUDA) is the best recognized. The respondents qualified four times the tools used as the most important for the elimination of waste. They included 5S, VSM, SMED and JIT, and then they indicated the suction system, standardization and the 5 x why method. The smallest use not only for the elimination of MUDUA but also MURI and MURA was pointed to the A3 report. It is clear from the data compiled in the table that it is the most difficult to reduce the MURI, i.e. overloading resources. In the case of

eliminating volatility (MURA), instruments such as standardization, SMED and the suction system play the key role.

CONCLUSION

The issues discussed in this article regarding the implementation of the Lean concept in the ceramic sector of the SME sector and related barriers indicate that:

- Lean is currently in the centre of attention of the analyzed enterprise, as it is perceived as a concept that brings tangible results, mainly through the elimination of processes and activities that do not add value to the product and allows for resource-efficient management,
- Identification of barriers related to the implementation of Lean solutions is particularly important for the development of a strategy for the implementation and adaptation of methods and tools to the conditions in which ceramic plants, in particular the SME sector, operate,
- the ceramic industry encounters a much larger number of barriers when attempting to implement Lean tools, among which the greatest are considered to be threats resulting from the lack of specialized knowledge about this concept and staff shortages, as well as the lack of reference model for the implementation of lean tools in the ceramic industry, which is characterized by specific natural processes,
- key activities in overcoming barriers to Lean implementation in the ceramic industry are the education of the management staff and the development of a set of procedures and guidelines to facilitate the implementation of tools of this concept in a specific group of entities such as ceramic plants,
- Lean instruments are well known in the analyzed enterprise, but most often they are used in the field of MUDA elimination and most rarely in the area of MURI elimination.

Lean approach may be also very useful in variety of research and industrial activities e.g. materials science (Ulewicz, M. & Radzymińska-Lenarcik, E., 2014; Korzekwa, J. et al., 2016; Pietraszek, J. et al., 2016), biotechnology (Skrzypczak-Pietraszek, E. et al., 2018) or general industrial management (Ulewicz, R. & Kucęba, R., 2016).

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Abstract. The problem of implementation of the concept of Lean Manufacturing in the ceramic industry, based on the enterprise manufacturing ceramic fancy goods, is presented in this article. The most important information about the concept of Lean Manufacturing, as well as the current state of implementation of the Lean concept in the ceramic industry. Major barriers in the implementation of the Lean concept are identified and selected instruments of the Lean concept applied in individual areas of the waste elimination are assigned.

Keywords: Lean Manufacturing, ceramic industry, waste